

REMARKS

Claims 1 to 6 are pending in the application. Claim 1 is the only independent claim.

§103

Claims 1 to 6 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,338,765 to Statnikov in view of Lu (Materials Science and Engineering, R16 (1996) pp 161-221).

This rejection is respectfully traversed.

The Present Invention

The present invention provides a method of production of a steel product with a nanocrystallized surface layer by means of, in combination, an amorphous state surface layer created by ultrasonic impact treatment and heat treating the surface layer at an appropriate temperature of e.g., 100 - 500°C, for obtaining a nanocrystallized surface layer, the method of production of a steel product with a nanocrystallized surface layer characterized by comprising;

(1) subjecting a surface layer of a steel product to ultrasonic impact treatment impacting it by one or more ultrasonic indenters vibrating in a plurality of directions, then

(2) subjecting the surface layer subjected to the ultrasonic impact treatment to heat treatment to cause precipitation of nanocrystals.

Patentability

An important feature of the present invention is to apply impact treatment by means of impacting one or more ultrasonic indenters vibrating in a plurality of directions, which is different from the feature of ultrasonic impacting treatment of welded structures

or creating a white layer (amorphous layer) at the welded portion as disclosed by the '765 patent'. The specification of the present application at page 6, lines 15-30 discloses that:

In working by impacting making ultrasonic indenters vibrate in only one direction, the structure of the surface layer of the metallic product is developed, the crystal grains do not become equiaxial, and deform to pancake shapes. High angle grain boundaries are not formed.

Therefore, by using a plurality of ultrasonic indenters, making the tips of the ultrasonic indenters vibrate in a plurality of different directions, and impacting the surface layer of the metallic product, formation of texture is suppressed and the grains become equiaxial.

Further, by heat treating at a low temperature the surface layer of the metallic product subjected to the ultrasonic impact treatment, it is possible to make the surface layer nanocrystalline.

For these purposes, the specification further discloses at page 8, line 34 to page 9, line 11 that:

[A] plurality of ultrasonic indenters 2 are used bundled together. The bundled ultrasonic indenters 2 as a bulk are simultaneously made to vibrate in the vertical direction (Z4) and the horizontal direction (Z5). Therefore, a plurality of ultrasonic vibration apparatuses 1 are provided.

By making the ultrasonic indenters 2 vibrate simultaneously in the vertical direction and horizontal direction and impact the surface layer of the metallic product, it is possible to suppress the formation of texture and make the crystal grains equiaxial.

Further, after this, it is possible to heat treat the surface layer of the metallic product at a low temperature to cause precipitation of nanocrystals and make the surface layer nanocrystalline.

On the other hand, the '756 patent' does not disclose or suggest the characteristic feature of the present invention, which has a nanocrystallized surface layer, and the formation of nonocrystallized surface layer by the steps defined in the production process as claimed in claim 1, including vibrating in a plurality of directions.

Lu discloses that polycrystalline materials with nanometer-sized grains, termed nanocrystalline materials, can be formed by crystallizing completely amorphous solids under proper heat treatment (annealing) at an appropriate temperature (about $T_a/Am-0.5$). However, the resultant material obtained by Lu has a nanocrystallized structure in the entire thickness of bulk material. There is no disclosure or suggestion in Lu of how to obtain a nanocrystallized surface layer on a steel product.

This means that Lu only discloses the nanocrystallized structure can be obtained by annealing an amorphous phase of Fe-base alloys to form a nanocrystallized bulk material. However, Lu does not disclose or suggest a steel product having a nanocrystallized surface layer formed by ultrasonic impact treatment of the surface and annealing of this surface layer.

Even if the '765 patent and Lu are combined, it is impossible to suppress the formation of texture and make the crystal grains equiaxial, and it is impossible to heat treat the surface layer of the metallic product at a low temperature to cause precipitation of nanocrystals and make the surface layer nanocrystalline.

Therefore, the characteristic feature of the present invention cannot be derived from the combined teachings of the '765 patent and Lu.

It is therefore submitted that independent claim 1, and claims 2 to 6 dependent thereon, are patentable over the '765 patent in view of Lu.

CONCLUSION

It is submitted that in view of the foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application be allowed and passed for issue.

Respectfully submitted,

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